Clean Water Supply Management In Bandar Lampung City Using NBS (Nature-Based Solution) System

Hambali Hambali[1*], Endro P. Wahono[2]

[1]Department of Civil Engineering, Faculty of Engineering, University of Lampung, Lampung, Indonesia
[2]Department of Civil Engineering, Faculty of Engineering, University of Lampung, Lampung, Indonesia
*hambali271977@gmail.com

Abstract. The provision of potable water is among the objectives of sustainable development, as outlined in the 2030 Sustainable Development Goals (SDGs). Clean water is one of the basic needs for the quality and sustainability of human life, absolutely must be available in adequate quantity and quality. The carrying capacity of raw water is increasingly limited, due to water pollution as a result of low public awareness, poor water catchment area management, and climate change, is an important environmental issue to be addressed. The presence of water resources within a region holds significant importance in fostering economic development, as rapid progress in an area is contingent upon the provision of fundamental amenities and infrastructure, including potable water facilities and infrastructure. The research location is in Bandar Lampung City. Nature-Based Solutions (NBS) have the capability to safeguard, oversee, and rejuvenate ecosystems. The concept of Nature-Based Solutions (NBS) is founded on five key pillars: restoration, social considerations, infrastructure, governance, and conservation. NBS endeavors to effectively and adaptively tackle both social challenges and environmental issues.

Keywords: Clean Water, Nature Based Solution, SDGs.

1 Introduction

Nature Based Solution (NBS) focuses on water management that can be applied in urban areas [1]. The NBS system is capable of coordinating several systems in urban areas so that they are integrated with water treatment [2]. So, later it will be directly related to conservation, synergy, policy integration, forest recovery landscapes, to the ecosystem approach, an event related to the storage and management of water quality. He explained that climate change affects the occurrence of extreme rainfall which often causes floods. Therefore, it is necessary for the role of nature and infrastructure built by humans to be able to overcome this. Basically, all these interconnected things are concepts from the NBS, Climate change causes heat waves on earth which indirectly cause higher disease transmission [3]. The transmission of this disease forces an in-

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crease in public health by building related infrastructure. Thus, infrastructure development is able to provide economic opportunities for the community. Even though NBS focuses on water management, the social benefits of NBS also affect economic and other aspects [4].

Fig. 1. Nature Based Solutions.

2 Methodology and Result

In general, the total volume of water on Earth remains relatively constant over time [5][6]. The hydrologic cycle concept posits that the quantity of water within a specific region of the Earth's surface is shaped by the inflows and outflows it experiences. During daylight hours, the presence of sunlight initiates the transformation of water on the Earth's surface into water vapor through evaporation and transpiration processes [7]. water vapor will rise until it condenses to form clouds. Due to ongoing cooling processes, water droplets within clouds progressively grow in size until they precipitate as rain. Moreover, the rainwater will permeate into the ground, becoming groundwater, or it will flow into surface water bodies, eventually shaping rivers, lakes, or wetlands. This method of understanding the water cycle involves quantifying it through water balance calculations. Land water balance entails estimating the accessibility of water within a specific land area characterized by a particular type of land cover.

The availability of water on earth is a dynamic system, meaning it always changes from time to time. Water balance is an explanation of the balance relationship between incoming flow (inflow) and flow out (outflow) of water in an area expanse of land in a certain period [8][9]. Where the land water balance is a breakdown of changes in water storage exist in a certain environment during a certain period [10]. The land water balance is an estimate of the availability of water that is at a certain land with a certain type of cover. Availability of water are part of natural phenomena, often difficult to regulate and predict accurately.

This is because the availability of water contains a high level of spatial variability and temporal variability [11]. Considering that the environmental carrying capacity cannot be limited by administrative area boundaries, spatial planning implementation must consider ecological linkages, effectiveness, and efficiency of resource utilization, while its management should focus on inter-regional cooperation.

The methodology for determining the water carrying capacity in a given area involves considering both the availability and demand for water resources to accommodate the needs of the local population [12]. Through this approach, it is possible to ascertain in broad terms whether water resources within a region exhibit a surplus or a deficit. A surplus state signifies that the water availability within an area is adequate, whereas a deficit state indicates that the area is unable to fulfill its water requirements.

The outcomes derived from employing this methodology can serve as inputs or factors to be considered in formulating spatial planning and assessing land use within the framework of ensuring sustainable water resource management [13]. The evaluation of water carrying capacity involves a comparison between water availability and demand, referencing Minister of Environment Regulation No. 17 of 2009.

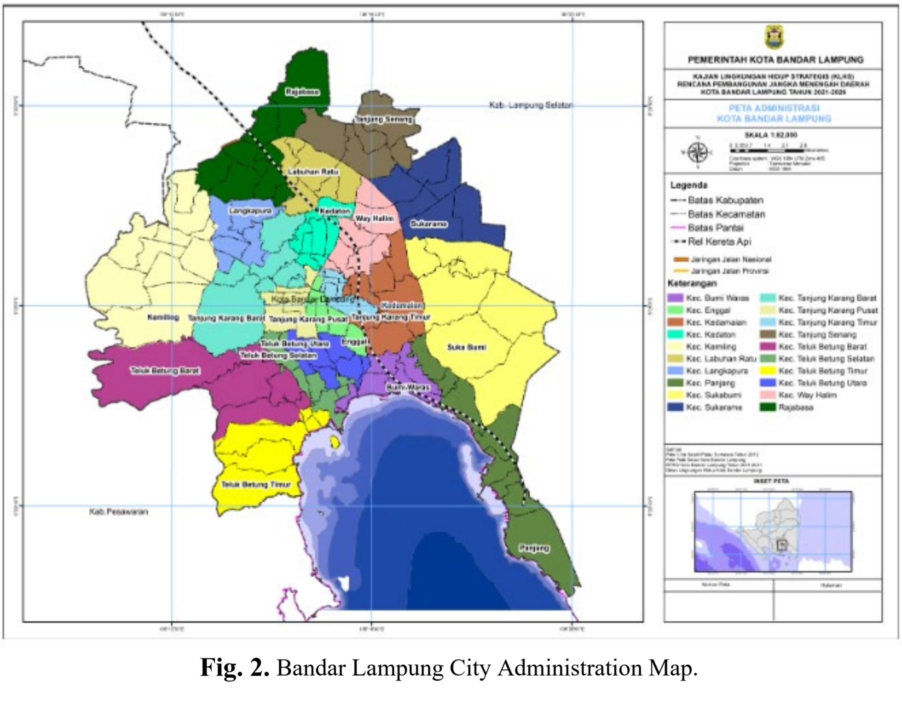

Fig. 2. Bandar Lampung City Administration Map.

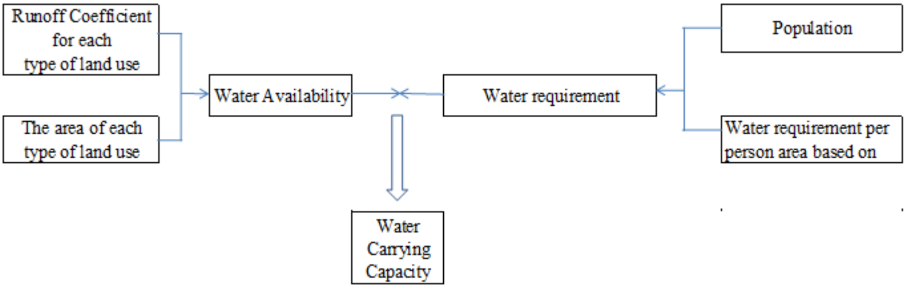

Fig. 3. Determinants of Water Carrying Capacity.

Water availability is assessed through the utilization of the runoff coefficient technique, which relies on land use data and annual rainfall information.

C = ∑ (ci x Ai) / ∑AiR = ∑ Ri / mSA = 10 x C x R x A

Description:

SA = Water availability (m^3/year)
C = Weighted runoff coefficient
Ci = Land use runoff coefficient i
Ai = Area of land use i (ha) from BPS data or Regions in Figures (Table III.15)
R = Average annual rainfall of the region (mm/year) from BPS data or BMG or related agency
Ri = Annual rainfall at station im = number of rainfall observation stations
A = Total area (ha)
10 = Conversion factor of mm. ha to m

Recapitulation of Land Use Area to Water Carrying Capacity City of Bandar Lampung.

Coefficient of Total Surface Water Carrying Capacity = 78.29,05/18,348 = 0.43

SA = 10 x C x R x A
SA = Surface water availability
C = Runoff coefficient
R = Rainfall/year
A = Area

Table 1. Coefficient of Total Surface Water Carrying Capacity.

Land Use	Area (Ha)	Coefficient	Area x Coefficient
Industrial, commercial and office buildings	864	0.18	155.52
Village residential buildings	230	0.18	41.4
City residential buildings	8,677	0.18	1,561.86
Medium density lowland forest	4.962	1	4,962
Forest, green belts and city parks	81	1	81
Road	88	0.9	79.2
Another freshwater pool	9	1	9
Moor fields with palawija	224	0.21	47.04
Other open land	69	0.21	14.49
The field is hardned	10	0.18	1.8
Golf course	43	0.21	9.03
Harbor	42	0.18	1.8
Public cemetery	16	0.3	4.8
Other open pit mining	155	0.18	27.9
Other planation	15	0.21	3.15
Rice field with rice continuously	946	0.46	435.16
Bushes and thickets	1,878	0.21	394.38
Stadium and sports facilities	7	0.18	1.26
Station	5	0.18	0.9
River	12	1	12
Fish pond	6	0.98	5.88
Terminal bus	9	0.18	1.62
Total	**18,348**		**7,829.05**

Source: Analysis Result of the 2021 KLHS RPJMD

Water availability in Bandar Lampung City is determined by applying a weighted runoff coefficient, which is calculated based on the land cover characteristics of each district. The calculations are facilitated through the utilization of geographic information systems (GIS) analysis to effectively map the surface water carrying capacity of each district area.

Water needs in Permen LH No. 17 of 2009 amounting to 1,600 m3/year. The per capita requirement for both domestic and non-domestic potable water is subsequently multiplied by the population count within each sub-district of Bandar Lampung City. The results of calculating the water carrying capacity of the city of Bandar Lampung occur in the following Table.

Table 2. Calculating the water carrying capacity of the city of Bandar Lampung.

No	District	Amount Resident	Water needs (M3/Year)	Availability Water (M3/Year)
1	Bumi Waras	63,166	101,065,600	2,157,001.92
2	Enggal	28,649	45,838,400	1,124,545.68
3	Kedamaian	57,905	92,648,000	6,353,131.56
4	Kedaton	57,339	91,737,600	1,523,595.21
5	Kemiling	88,574	141,718,400	22,233,314.20
6	Labuhan Ratu	52,393	83,828,800	2,483,141.55
7	Langkapura	42,569	69,710,400	2,038,633.24
8	Panjang	80,811	129,297,600	13,931,944.09
9	Rajabasa	57,589	92,142,400	7,124,692.62
10	Sukabumi	75,870	121,392,000	23,662,163.46
11	Sukarame	67,725	108,360,000	5,782,810.90
12	Tanjung Karang Barat	65,554	104,886,400	13,686,952.29
13	Tanjung Karang Pusat	55,925	89,480,000	2,139,900.91
14	Tanjung Karang Timur	43,076	68,921,600	933,166.37
15	Tanjung Senang	62,268	99,468,800	4,187,712.06
16	Teluk Betung Barat	41,096	65,753,600	29,708,291.59
17	Teluk Betung Selatan	42,870	68,592,000	2,298,79.48
18	Teluk Betung Timur	53,974	86,198,400	15,014,562.57
19	Teluk Betung Utara	53,552	85,683,200	1,678,135.06
20	Way Halim	74,364	118,982,400	2,785,135.60
	Total	**1,165,169**	**1,865,705,600**	**160,846,910.35**

Source : Analysis Result of the 2021 KLHS RPJMD

Status of Water Carrying Capacity Based on calculations of water availability and demand from 2021 to 2026, the status of water carrying capacity in Bandar Lampung City is in a deficit condition, meaning that it is no longer able to support domestic and agricultural activities. This process involves assessing the water quality by juxtaposing the minimum water requirement per individual with the available volume of water in the city of Bandar Lampung. The determination of environmental carrying capacity based on water balance criteria extends beyond mere expressions of surplus or deficit alone [14][15], However, to accurately depict relative magnitudes, it is essential to articulate it in terms of supply and demand as well. The concept of supply delineates the quantity of water accessible within the region, typically represented by the average volume of rainfall in the area, whereas demand denotes the volume of water required based on factors determining water demand within Bandar Lampung City. When the ratio of supply to demand exceeds 2, the environmental carrying capacity falls within the safe classification. Meanwhile, ratios falling between 1 and 2 are classified as conditionally safe, and those below 1 are categorized as unsafe, indicating that the environmental carrying capacity has been surpassed [16][17][18]. Upon examining the comparison for Bandar Lampung City, it was observed that in 2020 and 2026, the ratio of water supply to demand indicated an unsafe condition, indicating a deficit. A comprehensive assessment of the water carrying capacity across the sub-districts of Bandar Lampung City is required.

Table 3. Water Carrying Capacity in the sub-Districts of Bandar Lampung City.

No	District	Tot. Population	Water needs (M3/Year)	Availability Water (M3/Year)	Rasio	Status
1	Bumi Waras	42,559	101,065,600	2,157,001.92	0.03	Defisut
2	Enggal	55,792	45,838,400	1,124,545.68	0.01	Defisut
3	Kedamaian	44,394	92,648,000	6,353,131.56	0.09	Defisut
4	Kedaton	65,415	91,737,600	1,523,595.21	0.01	Defisut
5	Kemiling	83,690	141,718,400	22,233,314.20	0.17	Defisut
6	Labuhan Ratu	44,611	83,828,800	2,483,141.55	0.03	Defisut
7	Langkapura	59,967	69,710,400	2,038,633.24	0.02	Defisut
8	Panjang	55,416	129,297,600	13,931,944.09	0.16	Defisut
9	Rajabasa	57,917	92,142,400	7,124,692.62	0.08	Defisut
10	Sukabumi	29,670	121,392,000	23,662,163.46	0.5	Defisut
11	Sukarame	67,887	108,360,000	5,782,810.90	0.05	Defisut
12	Tj. Karang Barat	91,728	104,886,400	13,686,952.29	0.09	Defisut
13	Tj. Karang Pusat	45,123	89,480,000	2,139,900.91	0.03	Defisut
14	Tj, Karang Timur	59,377	68,921,600	933,166.37	0.01	Defisut
15	Tanjung Senang	59,638	99,468,800	4,187,712.06	0.04	Defisut
16	Tel. Betung Barat	64,381	65,753,600	29,708,291.59	0.29	Defisut
17	Tel. Betung Selatan	54,259	68,592,000	2,298,79.48	0.03	Defisut
18	Tel. Betung Timur	70,136	86,198,400	15,014,562.57	0.13	Defisut
19	Tel. Betung Utara	78,565	85,683,200	1,678,135.06	0.01	Defisut
20	Way Halim	77,013	118,982,400	2,785,135.60	0.02	Defisut
	Total	**1,207,538**	**1,865,705,600**	**160,846,910.35**	**0.09**	**Defisut**

Source : Analysis Result of the 2021 KLHS RPJMD

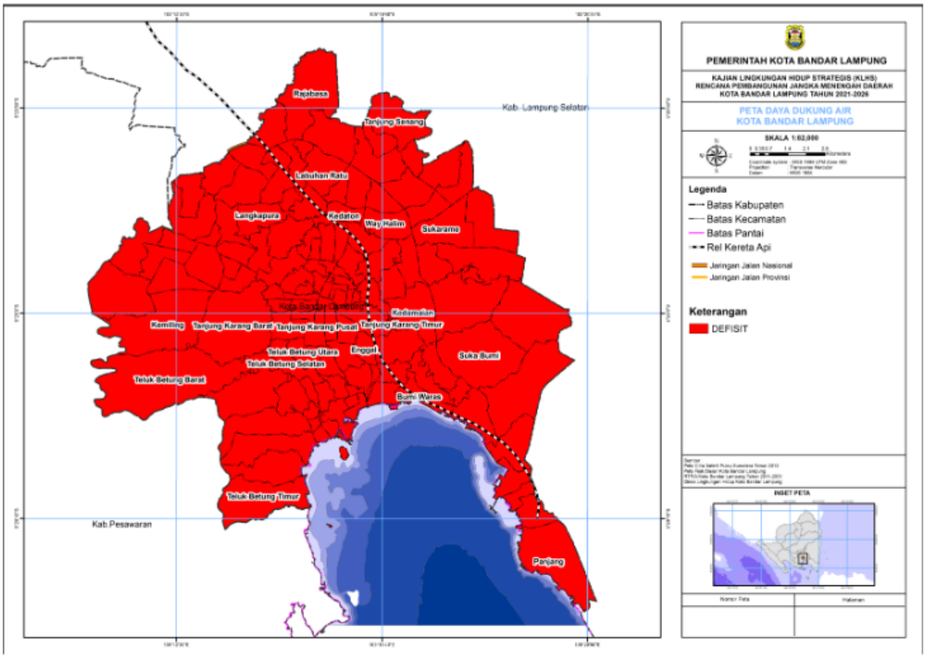

Fig. 4. Water Carrying Capacity Status Map.

The quality of water is assessed based on its physical, chemical, and biological attributes, serving as indicators of its overall condition [19]. Water quality additionally reflects the suitability of water conditions in meeting the requirements of both aquatic organisms and human beings. Water quality frequently serves as the benchmark for assessing the vitality of aquatic ecosystems and ensuring human health through potable water sources. The fluctuation of water conditions over time is contingent upon the intricacies of local environmental dynamics. Given its intimate association with local ecological settings, water quality presents a highly intricate domain within the realm of environmental science.

Industrial operations encompassing manufacturing, mining, construction, and transportation represent primary contributors to water pollution, alongside surface runoff originating from agricultural practices and urban environments [20][21]. To ascertain the continued quality of river water, an assessment is conducted by juxtaposing the measured or tested values of each parameter with established standards. In this instance, the river water quality standards outlined in Appendix VI of Government Regulation No. 22 of 2021 regarding the Implementation of Environmental Protection and Management serve as the benchmark. In Appendix VI of Government Regulation No. 22 of 2021 it is stated that there are four classes of river water (class I, class I, class III, class IV), each of which has a different designation. Class I is water which can be used for raw water. drinking, and or other uses that require the same quality of water as these uses. Class II, namely water that can be used for infrastructure/facilities for water recreation, freshwater fish farming, animal husbandry, water for irrigate crops, and or other uses that require water quality the same use. Class III, namely the designated water can be used for freshwater fish farming, animal husbandry, water for irrigate crops, and or other uses that require water quality the same use. Class IV, namely the designated water can be used to irrigate crops and or other designations requires the same quality of water as that use. In 2019, the Environmental Service of Bandar Lampung City conducted monitoring activities on river water to assess the water quality within the city of Bandar Lampung. The assessment of river water quality relies on the calculation of water pollution indices for each river [22].

The Water Pollution Index is calculated using 5 (five) main parameters water pollution namely TSS (Total Suspended Solid), DO (Dissolved Oxygen/Dissolved Oxygen), and COD (Chemical Oxidation Demand/Amount Oxygen to Oxidize Chemicals in water), BOD (Biological Oxidation Demand) and pH formulated with the following formula:

$$Pi = (\sqrt{(Ci/Li)\ max^2 + (Ci/Li)\ average^2})/2$$

C = concentration of the measured water parameter
L = parameter quality standard While the parameter quality standard is determined using Government Regulation No. 22 of 2021 with Class II Water.

Calculation of the Water Pollution Index uses the following steps:

1. One river is selected and one test is considered to represent one sample;
2. Calculate the pollution index for each parameter DO, TSS, COD, PH, BOD;
3. Calculate the percentage of the number of samples that have a PI value < 1;
4. $0 < Pi < 1$ (Meet BML / Good)$1<Pi >5.0$ (Slightly Polluted) $5.0< Pi >10$ (Moderately Polluted) $Pi> 10$ (Severely Polluted).

The status of river water quality in Bandar Lampung City can be seen in Table following:

Table 4. Status of River Water Quality in Bandar Lampung City.

No	Monitoring Point	Quality Status
1	Way Keteguhan	Lightly Polluted
2	Way Kuripan Hilir	Lightly Polluted
3	Way Sukamaju Hulu	Lightly Polluted
4	Way Sukamaju Hilir	Lightly Polluted
5	Way Simpang Kiri	Lightly Polluted
6	Way Simpang Kanan	Lightly Polluted
7	Way Kuripan Hulu	Good/Meet Quality Standards
8	Way Langkapura	Lightly Polluted
9	Way Awi Hulu	Lightly Polluted
10	Way alau Hulu	Lightly Polluted
11	Way Kunyit	Lightly Polluted
12	Way Kupang Hilir	Good/Meet Quality Standards
13	Way Lunik Hilir	Lightly Polluted
14	Way Galih Hilir	Lightly Polluted
15	Way Sukabumi	Good/Meet Quality Standards
16	Way Balau Hilir	Lightly Polluted
17	Way Galih Hulu	Lightly Polluted
18	Way Lunik Hulu	Lightly Polluted
19	Way Awi Hilir	Lightly Polluted
20	Way Cirebon Hilir	Lightly Polluted
21	Way Kuala Hilir	Lightly Polluted
22	Way Balau	Lightly Polluted
23	Way Cirebon Hulu	Lightly Polluted

Source: Bandar Lampung Environmental Service 2019

Based on the provided data, it is evident that in 2019, the Environmental Service of the City of Bandar Lampung conducted monitoring at 23 river monitoring points. The monitoring revealed that 3 rivers met the quality standards or exhibited good water quality, whereas 12 other rivers had slightly polluted water quality. The water quality index of Bandar Lampung city is determined based on the status value of river water quality standards [23].

So that the Bandar Lampung City Water Quality Index for 2020 can be seen on the following:

Table 5. Bandar Lampung City Water Quality Index for 2020.

River Water Quality Status	Amonth River	Amonth River	Amonth River	Amonth River
Fulfil	3	20%	70	14
Light	12	80%	50	40
Currently	0	0%	30	0
Heavy	0	0%	10	0
Amounth	15	100%		
Water Polution Index Value	54			

Source: Bandar Lampung Environmental Service 2021

Through the results of measurements of the water quality status at 15 (fifteen) points Observation of rivers in Bandar Lampung City obtained the results of the Water Quality Index in the City of Bandar Lampung with a value of 54. Based on the Pollution Index shows that 3 (three) rivers in Bandar Lampung City are still fulfilling quality standard or good condition and 12 (twelve) rivers in polluted condition light. Such conditions need to be a concern, because it has the potential to experience pollution with the status of heavily polluted if it is not carried out appropriate efforts to reduce various sources of pollution in the area rivers, such as controlling waste from residential areas and activities in area around the river that has the potential to pollute the river [24].

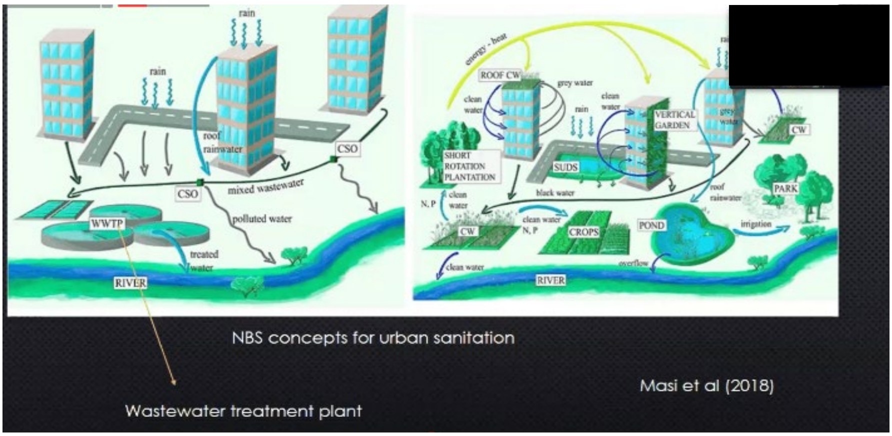

Fig. 5. NBS Concept for Urban Sanitation.

3 Conclusion

The aims, objectives and targets are:

1. Nature-based solutions transcend conventional biodiversity preservation and management paradigms by reorienting the discourse towards human-centric considerations, thereby intricately integrating socio-economic development, poverty alleviation, human well-being, and governance principles.
2. The restoration and safeguarding of mangroves along coastlines through the utilization of nature-based solutions serve a multitude of objectives. Mangroves act as natural buffers, attenuating the effects of waves and wind on coastal communities, while also sequestering carbon dioxide. Furthermore, they serve as vital nursery habitats for marine species, supporting fisheries crucial for local livelihoods. Additionally, mangrove forests play a crucial role in mitigating coastal erosion exacerbated by the rise in sea levels.
3. Nature-based solutions like green roofs or walls offer complex strategies for urban implementation, aiming to alleviate the effects of urban heat islands, capture stormwater runoff, mitigate pollution, sequester carbon, and enhance biodiversity.
4. For decades, efforts in conservation strategies and environmental management have been ongoing. However, there has been recent advancement in elucidating the myriad benefits that nature-based solutions offer to human well-being. Despite the ongoing evolution in the conceptual framing of this term, instances of nature-based solutions are already evident worldwide.
5. For decades, efforts in conservation strategies and environmental management have been ongoing. However, there has been recent advancement in elucidating the myriad benefits that nature-based solutions offer to human well-being. Despite the ongoing evolution in the conceptual framing of this term, instances of nature-based solutions are already evident worldwide.
6. Recent investigations have outlined methods for strategically planning and executing nature-based solutions within urban environments. Concurrently, these solutions are becoming increasingly integrated into prominent national and international policies and initiatives, encompassing climate change policies, legislative frameworks, infrastructure investments, and financial mechanisms. Notably, the European Commission has amplified its focus on nature-based solutions since 2013, recognizing them as an essential element of the EU's Research & Innovation policy.

The NBS has the capability to develop the World Water 2018 report by UN-Water, resulting in the accomplishment of the following objectives regarding water-related issues:

1. Use natural methods to increase the availability of water (such as retaining soil moisture and recharging groundwater), enhance water quality (including using natural and constructed wetlands for treating wastewater and implementing riparian buffer zones), and reduce the dangers linked to water-related disasters caused by climate change (such as restoring floodplains and implementing green roofs).

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